



Controlled and modified atmosphere systems

- Basic concepts of CA
- Effects of CA (physiological & biochemical effects)
- Potential benefits - harmful effects
- CA/MA requirements and recommendations
- CA/MA technology
- Oxygen control systems
- Carbon dioxide control systems
- Ethylene control systems
- Automation
- Safety

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In Modified Atmosphere (MA) or Controlled Atmosphere (CA) the atmospheric composition is different from the normal air

(78.08% N₂, 20.95% O₂, 0.03% CO₂)

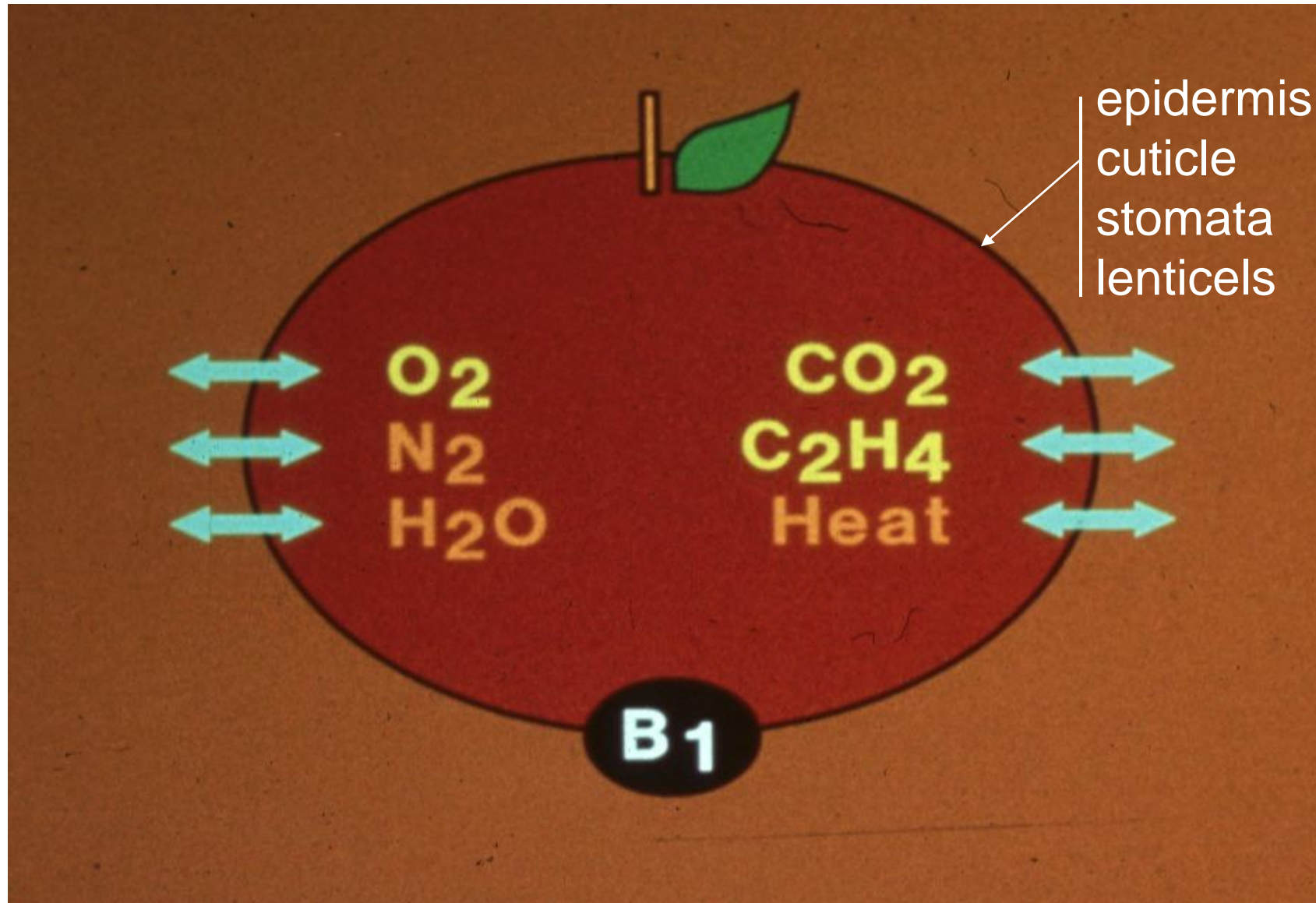
MA differs from CA in degree of precision in controlling O₂ and CO₂



Modified atmosphere involves:

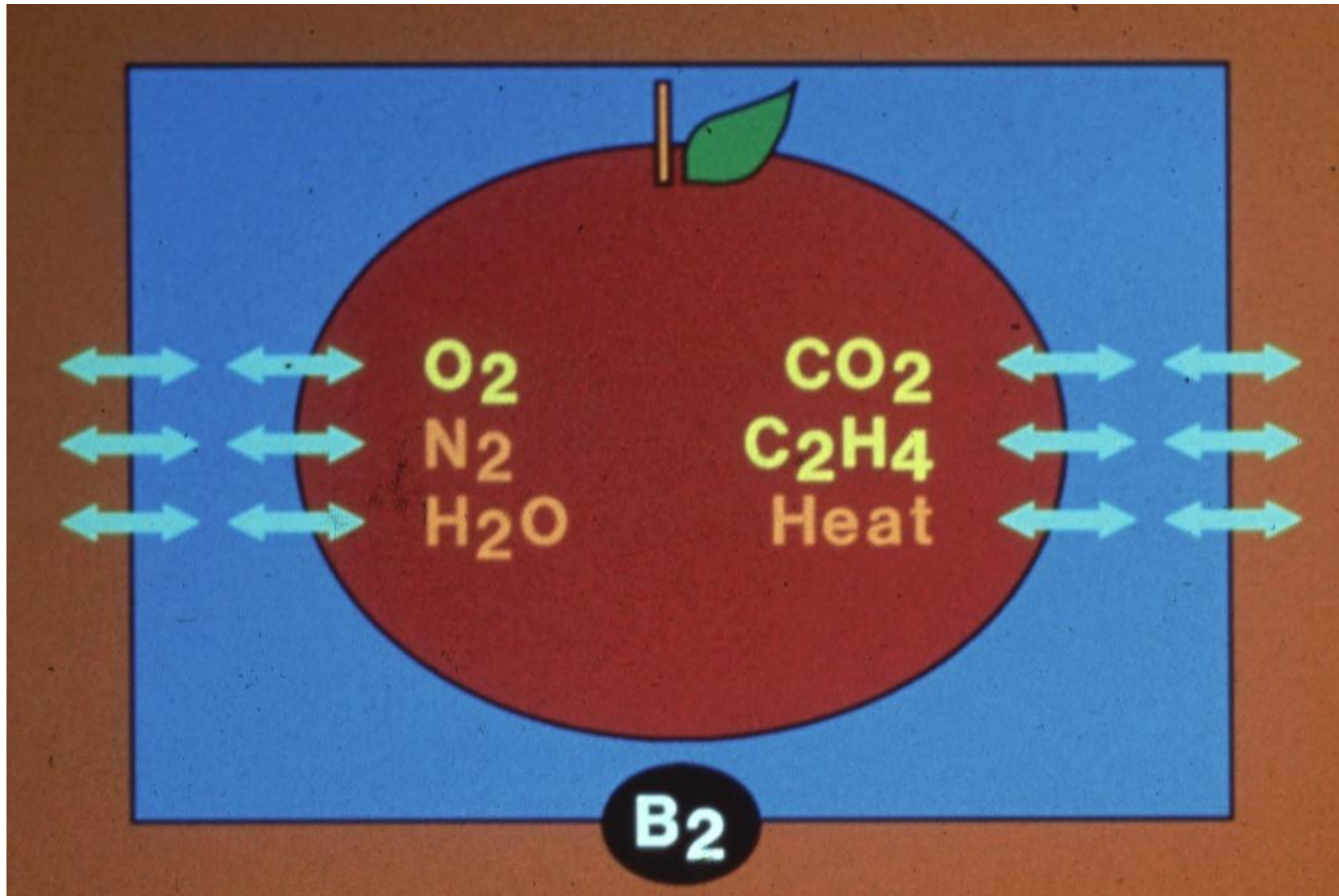
- Reducing oxygen
- Increasing carbon dioxide
- Adding carbon monoxide
- Removing carbon dioxide, ethylene and other volatiles

B1(commodity) depends on: Natural dermal system
(epidermis, cuticle, stomata, lenticels)
Added barriers (surface coatings, film wrapping)



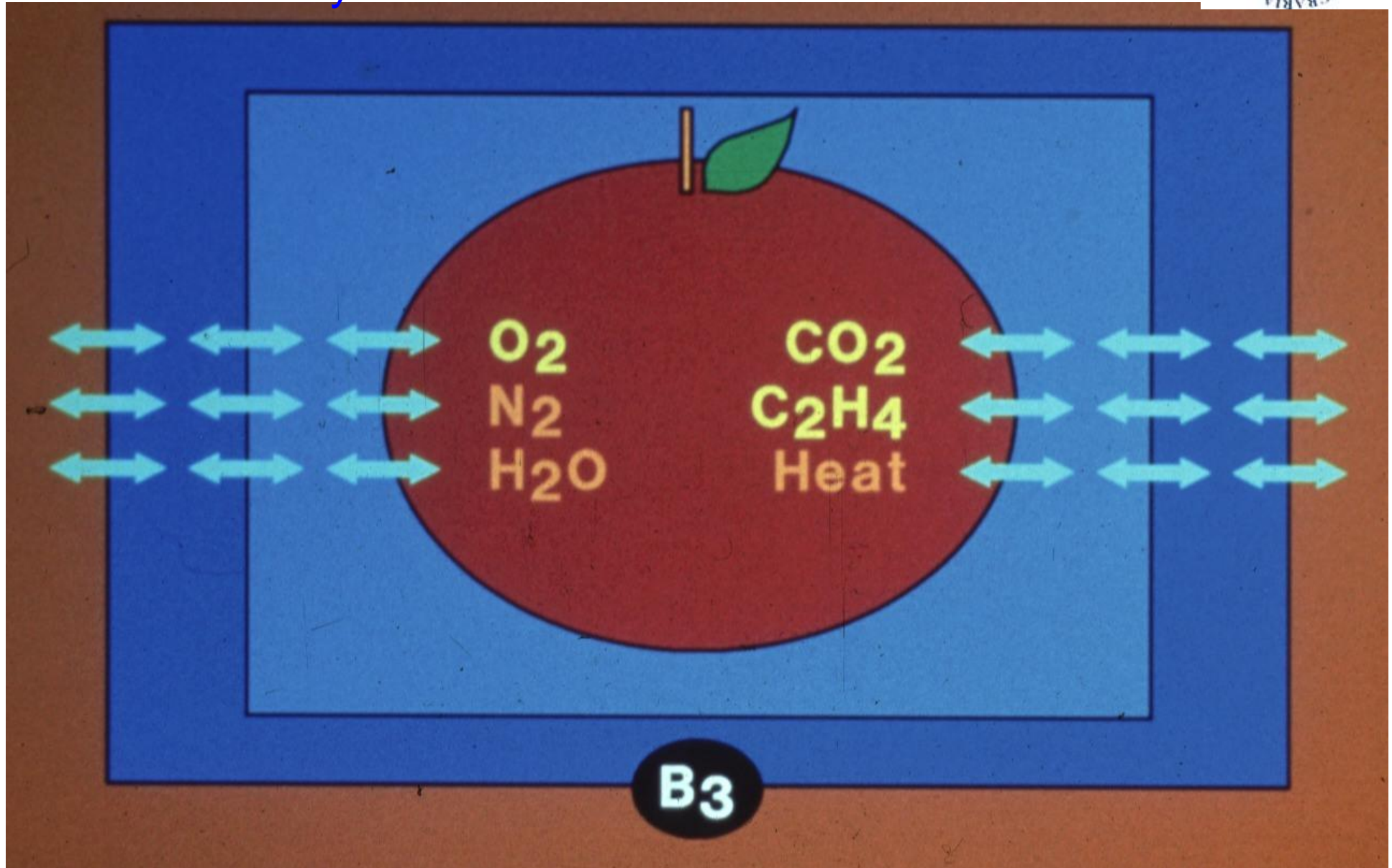
B2 (package) depends on:

- Permeability of packaging material
- Ventilation openings
- Plastic liners

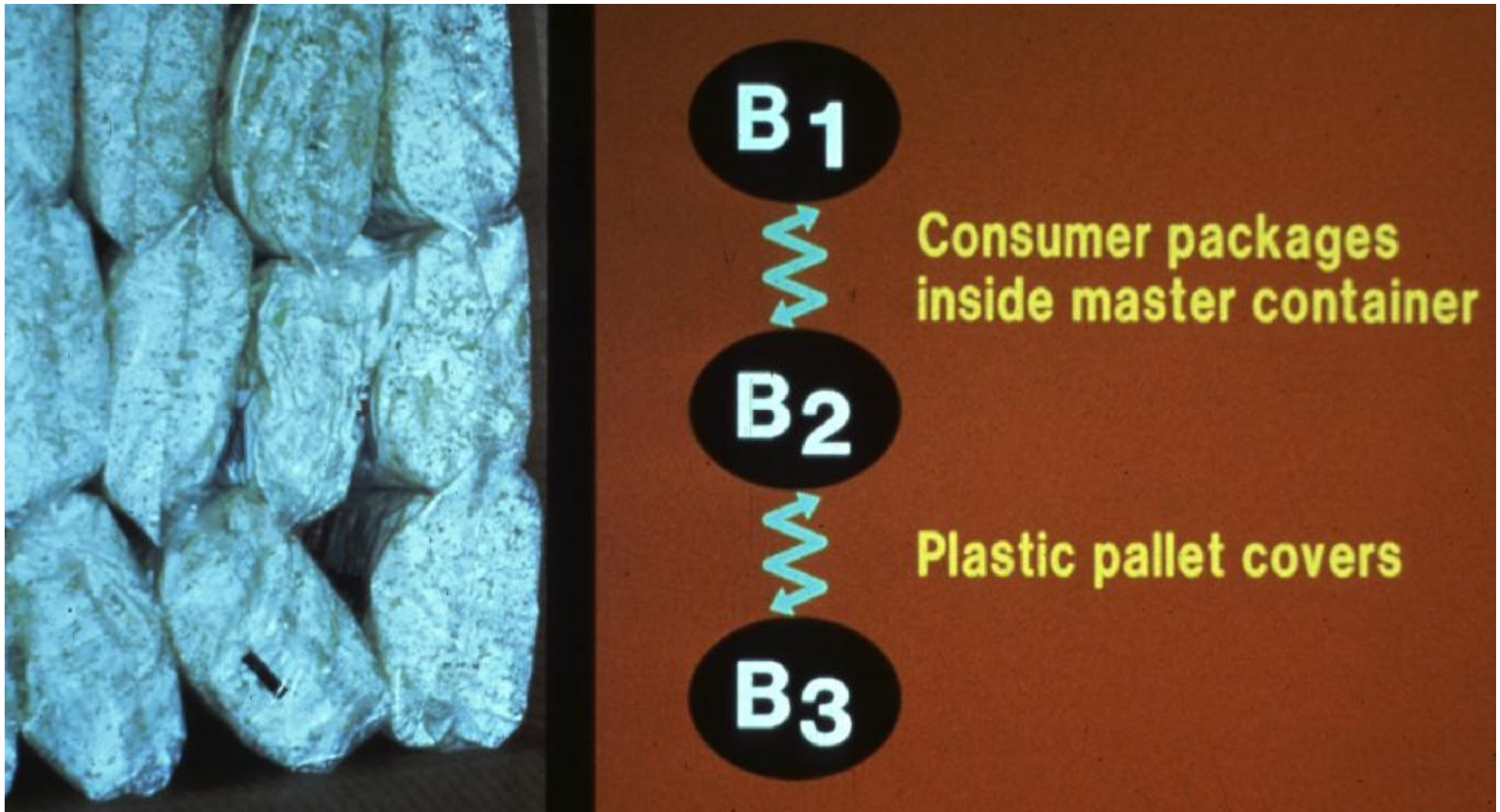


B3 (storage room/transit vehicles) depends on:

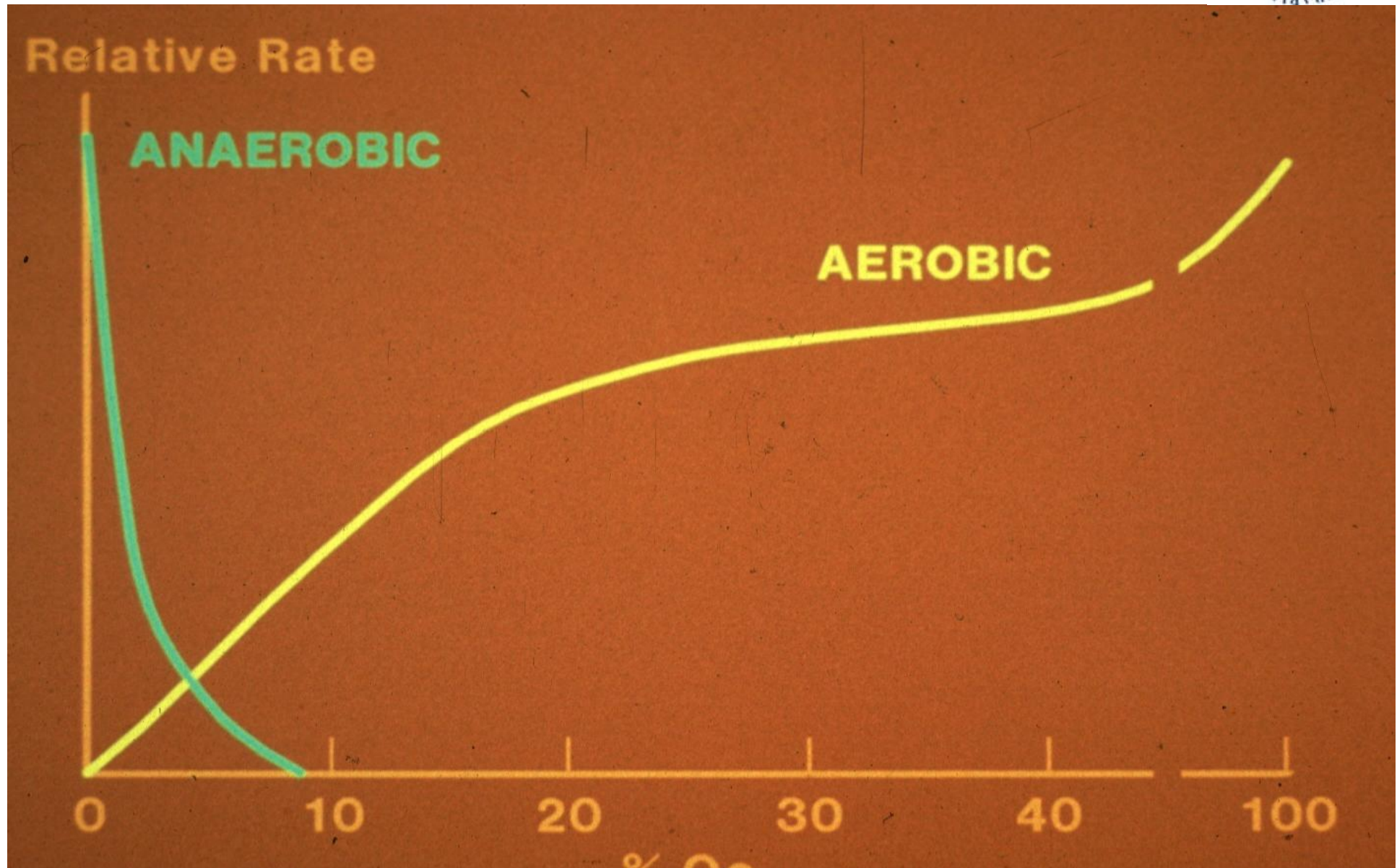
- Degree of gas tightness
- Ventilation system



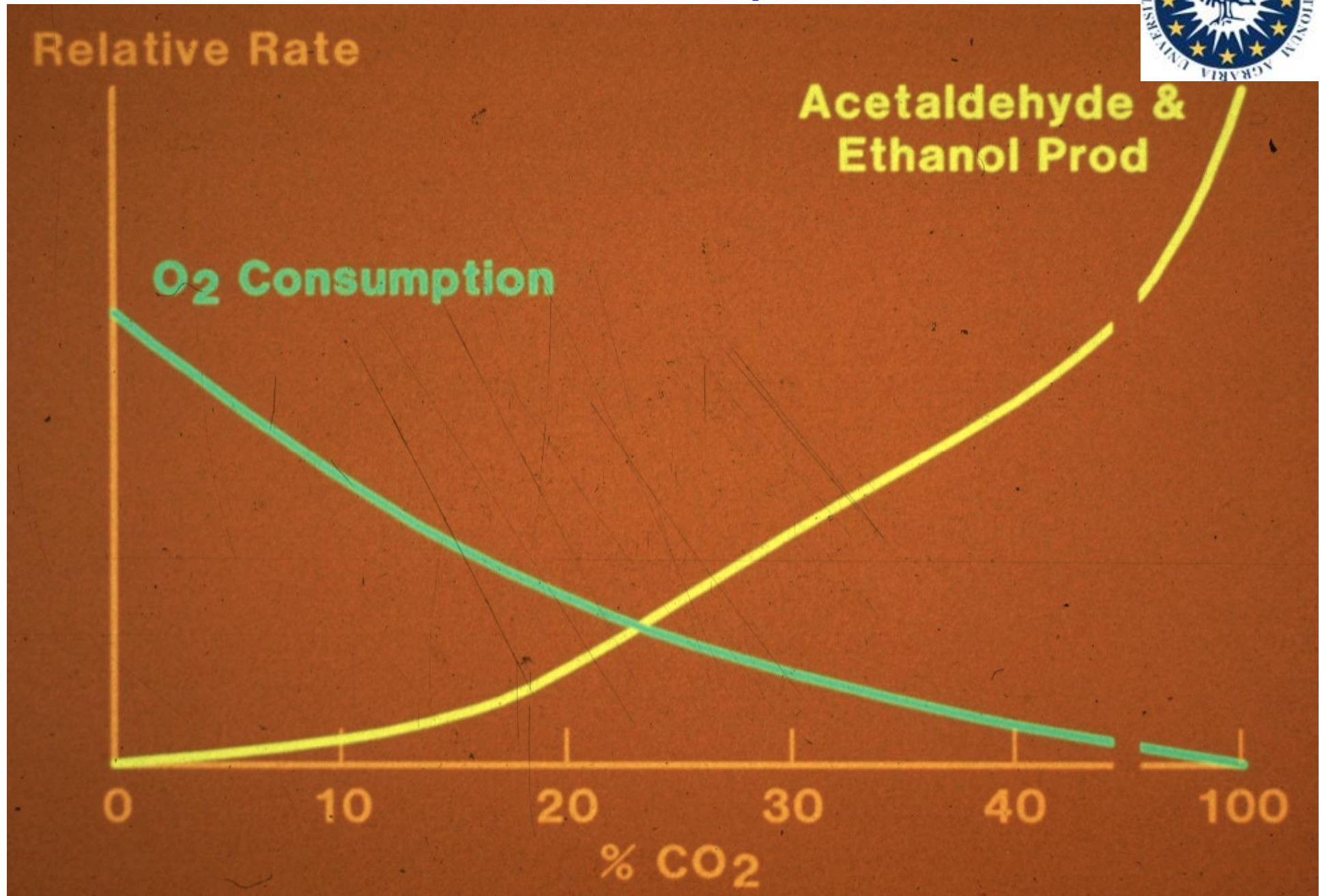
Additional barriers



Effect of oxygen level on respiration rates



Effect of CO₂ level on respiration rates





Modified Atmospheres

Potential for benefit or hazard depends upon:

- Commodity
- Variety (cultivar)
- Atmospheric composition
- Temperature
- Duration

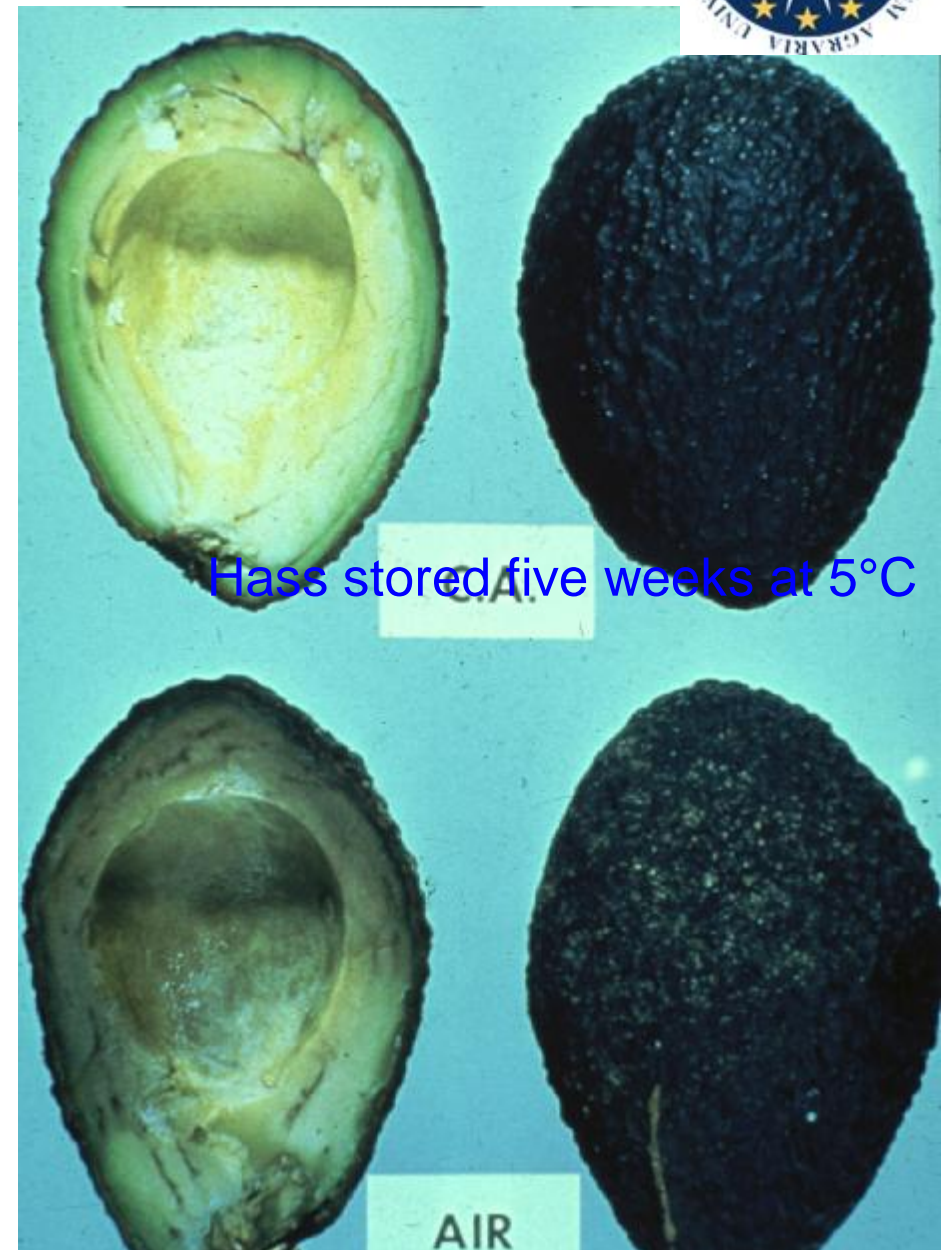
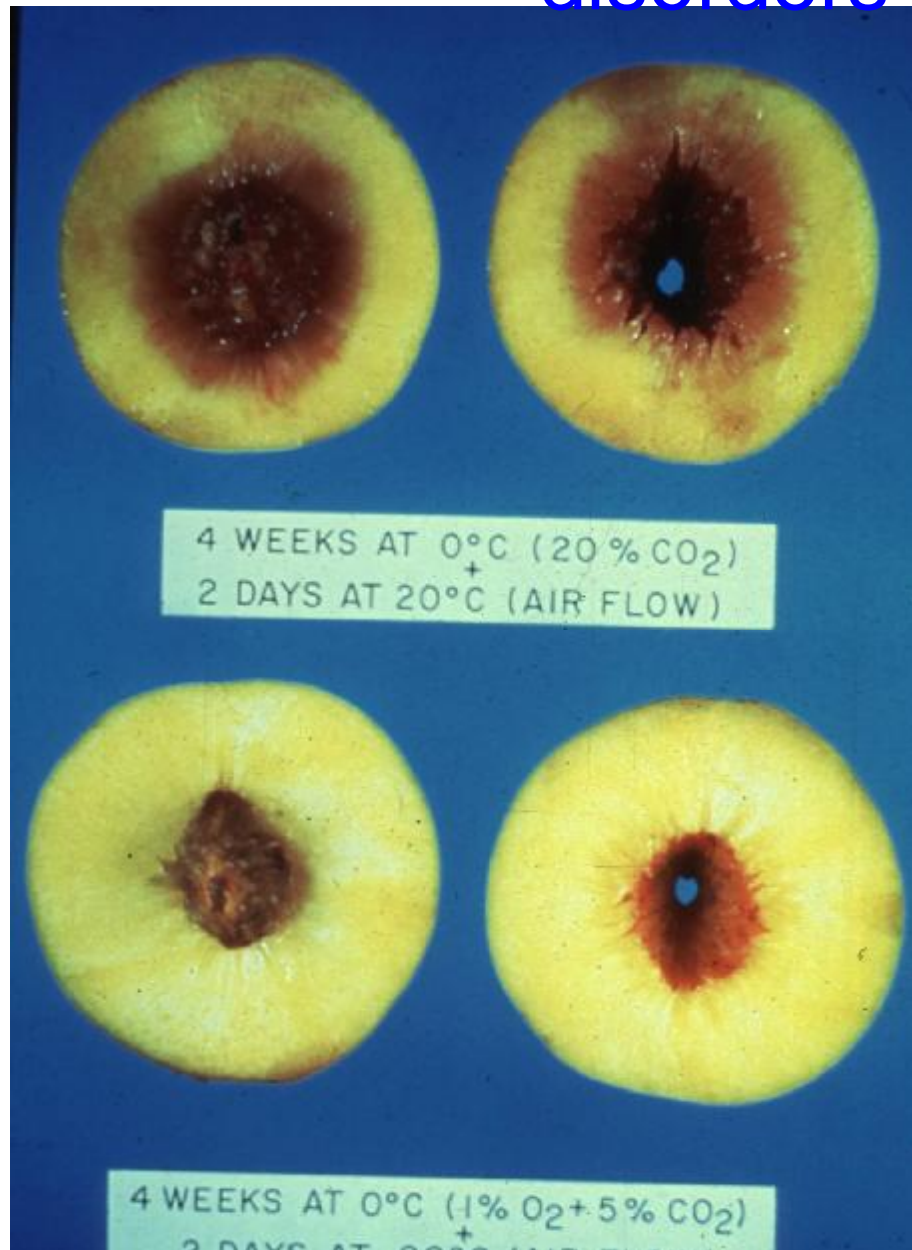


Modified Atmospheres

Potential benefits

- Retards senescence (ripening)
- Reduce ethylene sensitivity
- Alleviate certain physiological disorders
- Controls decay
- Controls insects

Benefits-Alleviation of physiological disorders

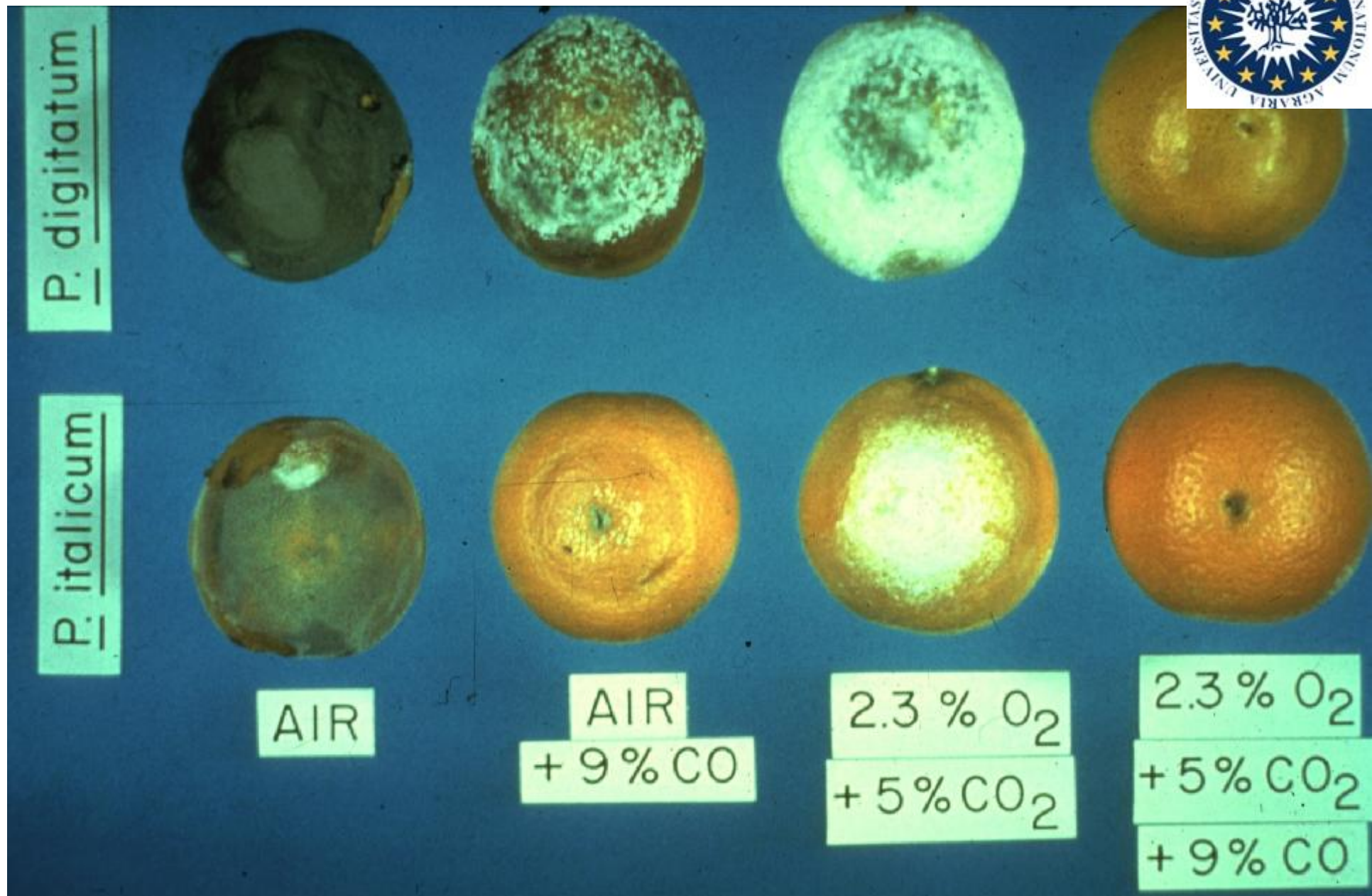


Hass stored five weeks at 5°C

Beneficial effects



Beneficial effects



The effect of ULO storage in Granny Smith apples

Jonathan apples



Control

1%O₂

0.7%O₂

Control

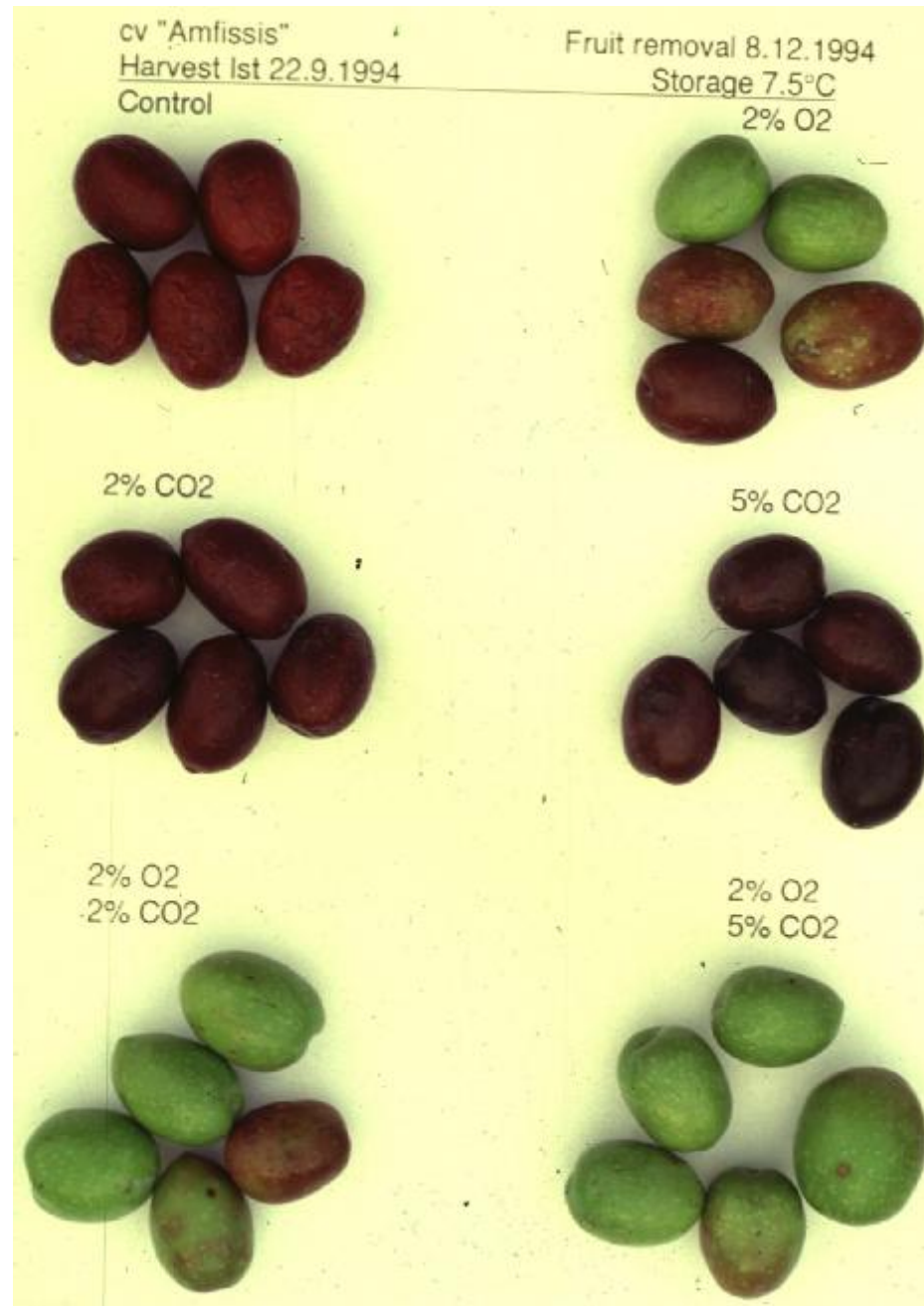
1%O₂

0.7%O₂

Air Air+C₃H₆ 5% O₂+ C₃H₆ 1% O₂+ C₃H₆
5%O₂+ C₃H₆ 2% O₂+ C₃H₆



The effect of CA storage in table olives: cv Amfissis





Modified Atmospheres

Potential hazards

- Aggravate physiological disorders
- Causes irregular ripening
- Induces off-flavors/odors
- Increases decay susceptibility



control

10% CO₂

20% CO₂



Methods of atmospheric modification

Atmosphere generators for:

- Oxygen removal
- Carbon dioxide removal
- Carbon dioxide addition
- Removal of ethylene and other volatiles

Hypobaric (low pressure storage) systems

Commodity generated MA



Commodity generated MA

- Use of air-tight storage rooms
- Use of plastic covers with diffusion windows
- Use of pallet shrouds
- Manipulation of shipping container vents
- Use of polyethylene liners in shipping containers
- Packaging in film wraps or bags
- Waxes and other surface coating



Atmosphere modification

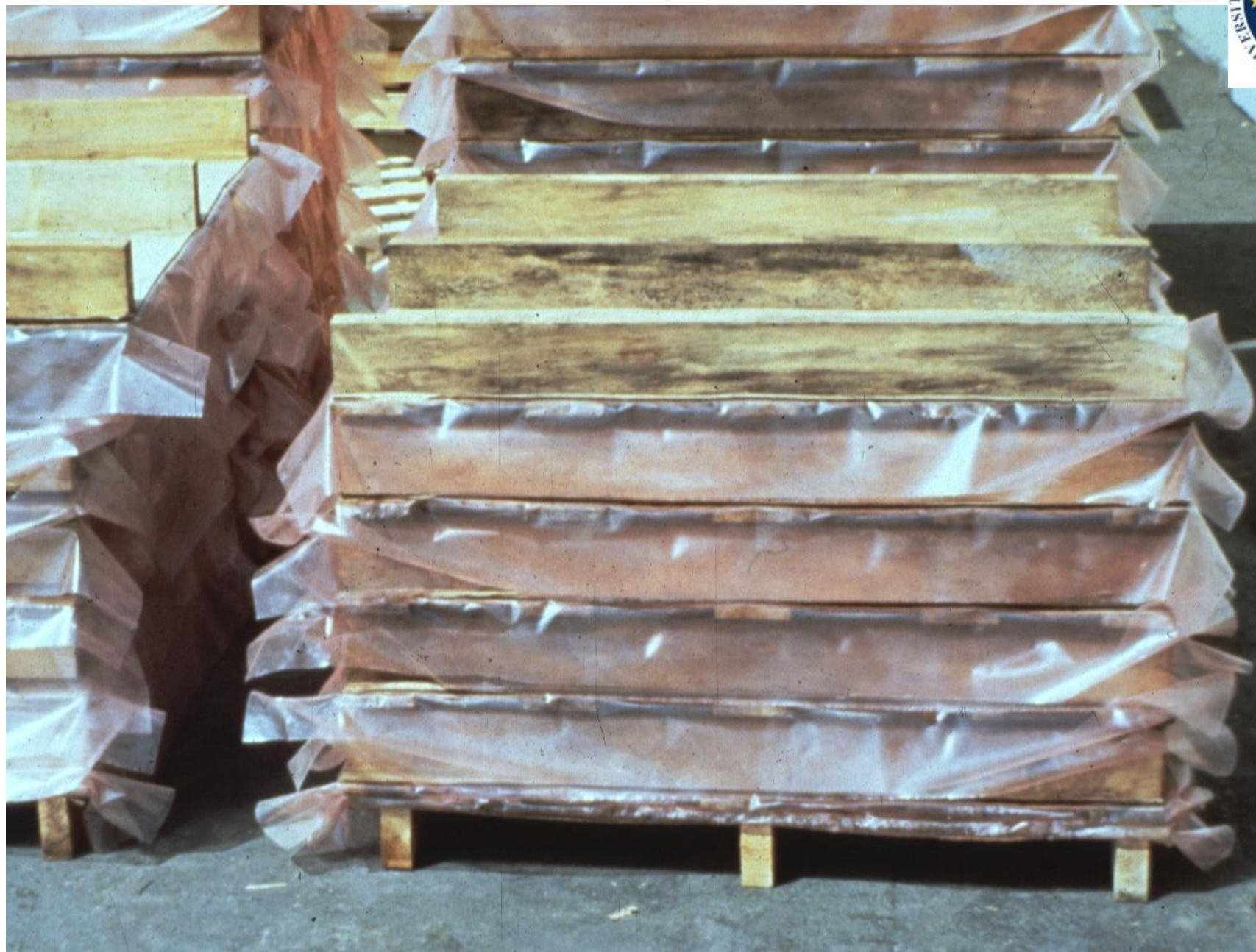
Polymeric film packages

- Film permeability
(depends upon type, thickness, and surface area of film)
- Commodity respiration rate
(depends upon type, maturity, quantity in a package, temperature)
- Other factors:
initial free volume and atmospheric composition in package,
external environment













Commercial CA generating equipment

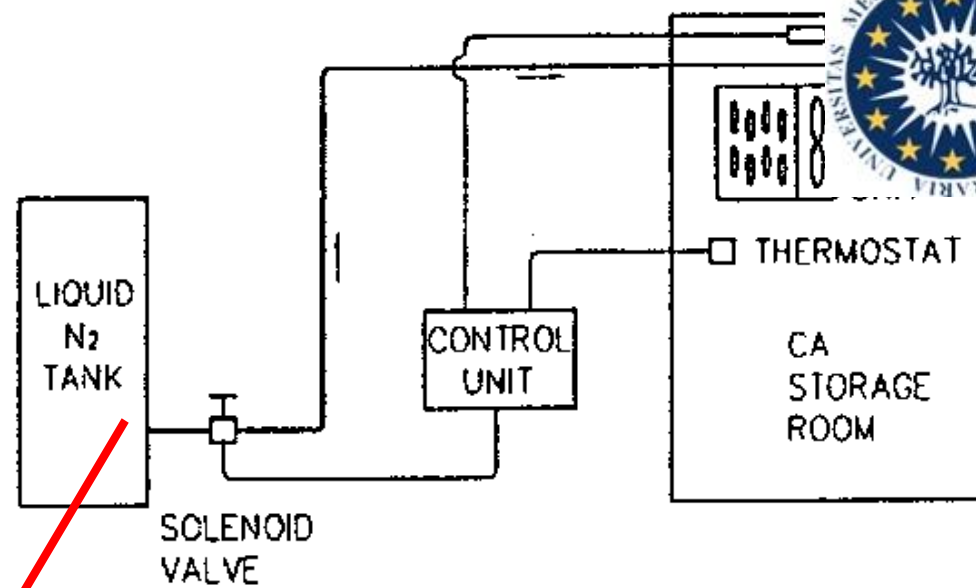
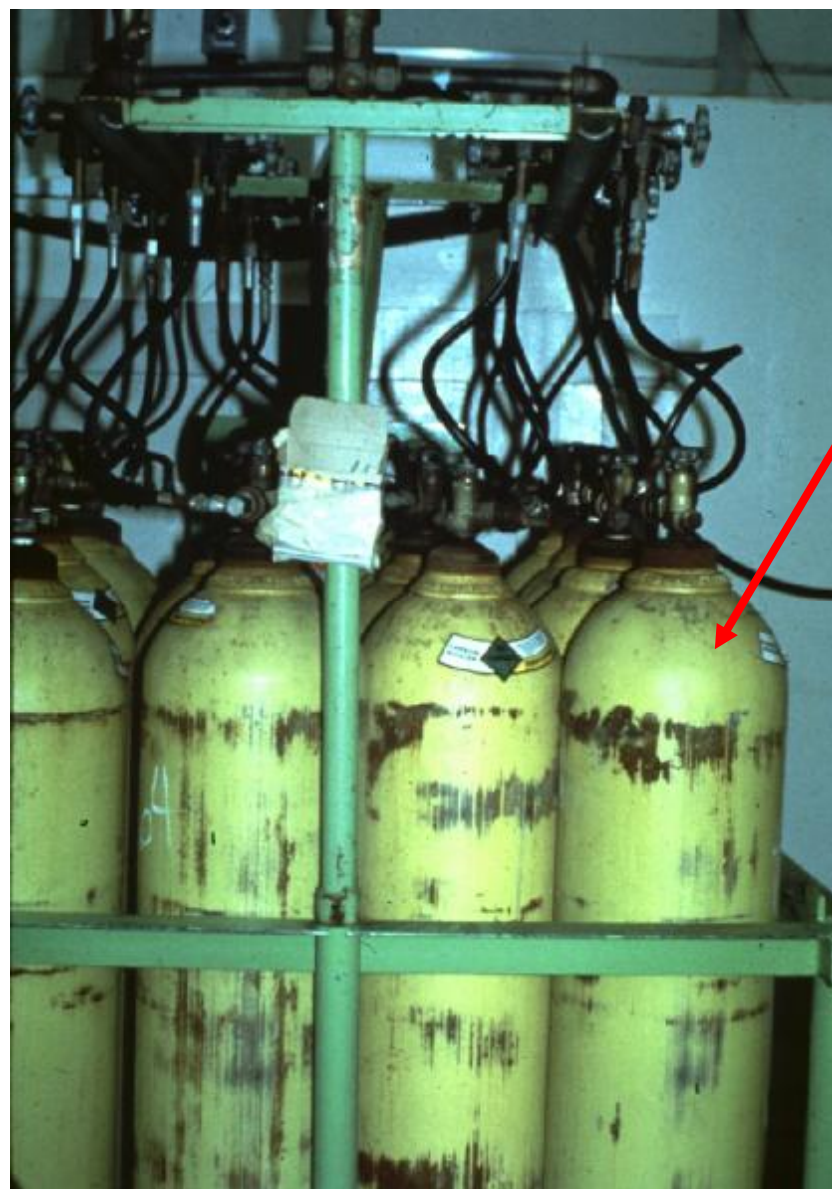
Oxygen reduction

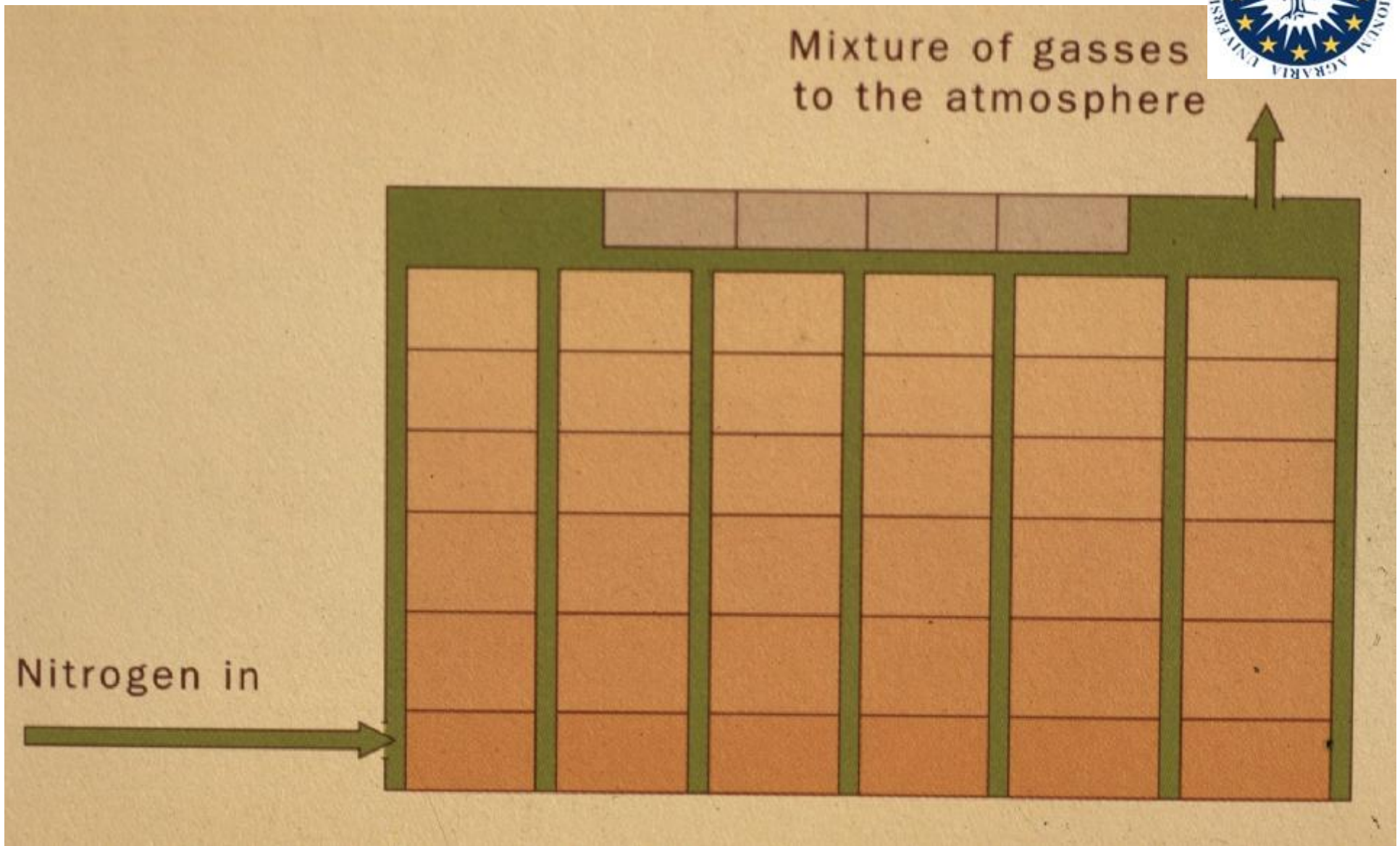
Burning oxygen

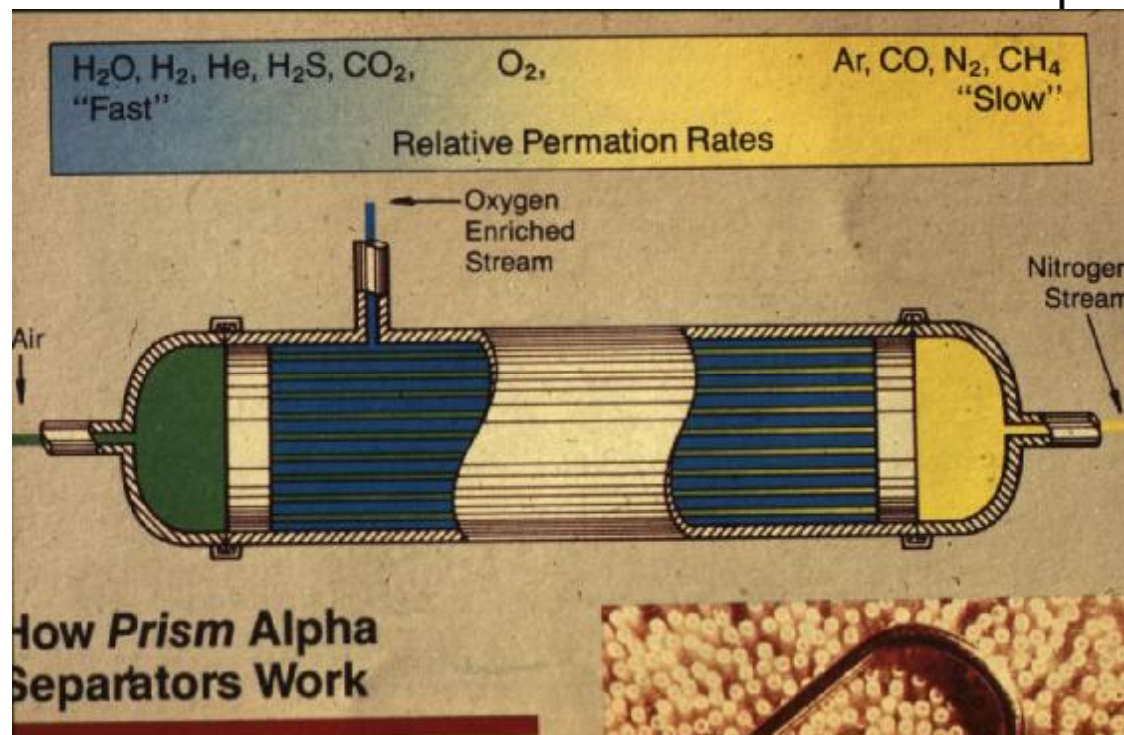
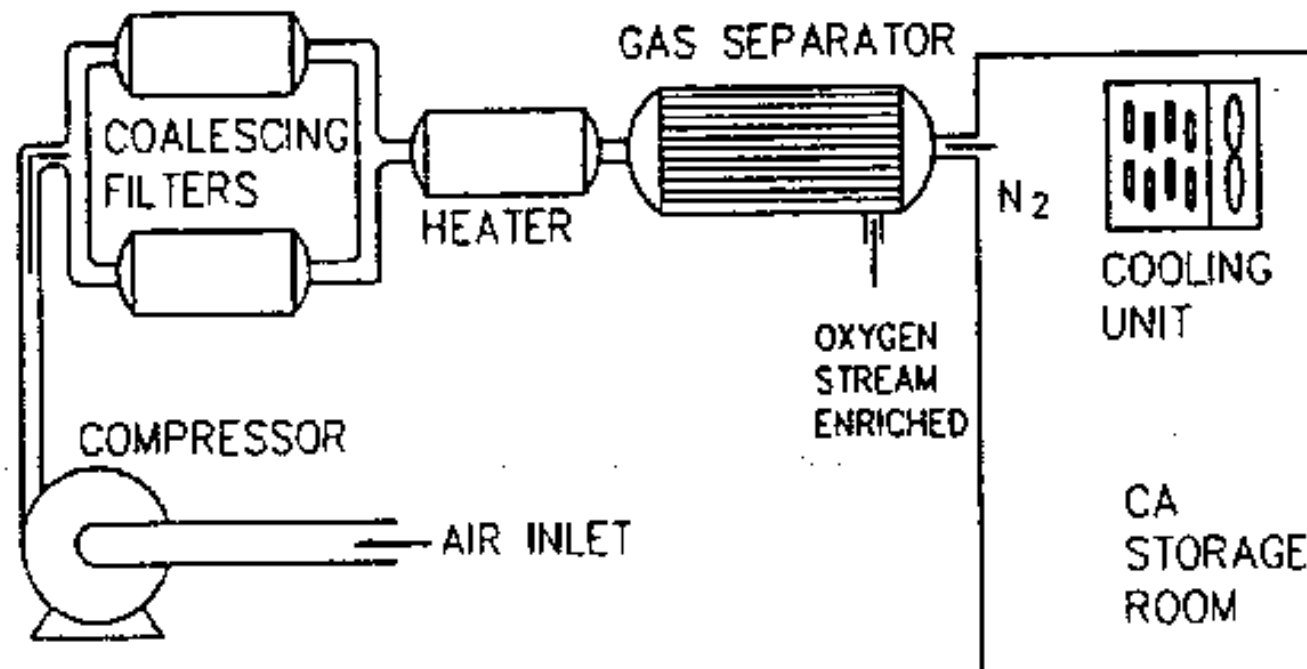
- Open flame burners
- Catalytic oxygen burners

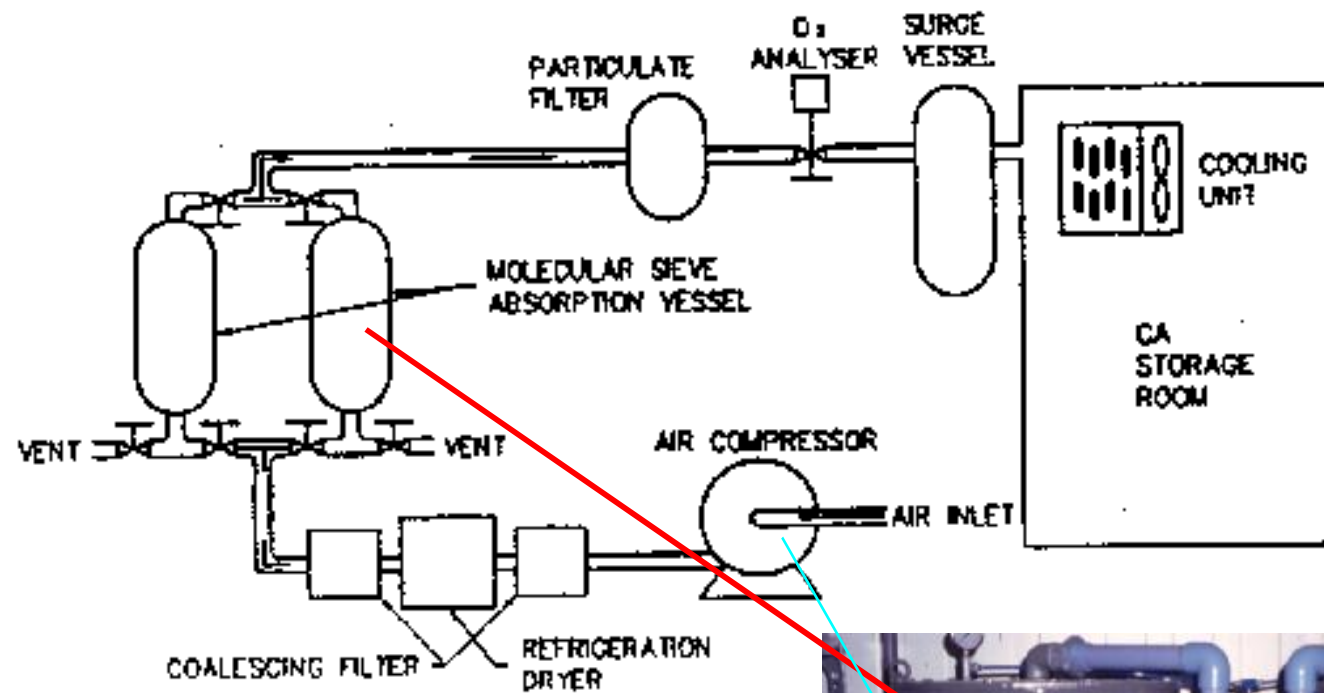
Purging with nitrogen

- Liquid nitrogen
- Nitrogen separated from compressed air by
 - Molecular sieve system
 - Membrane system







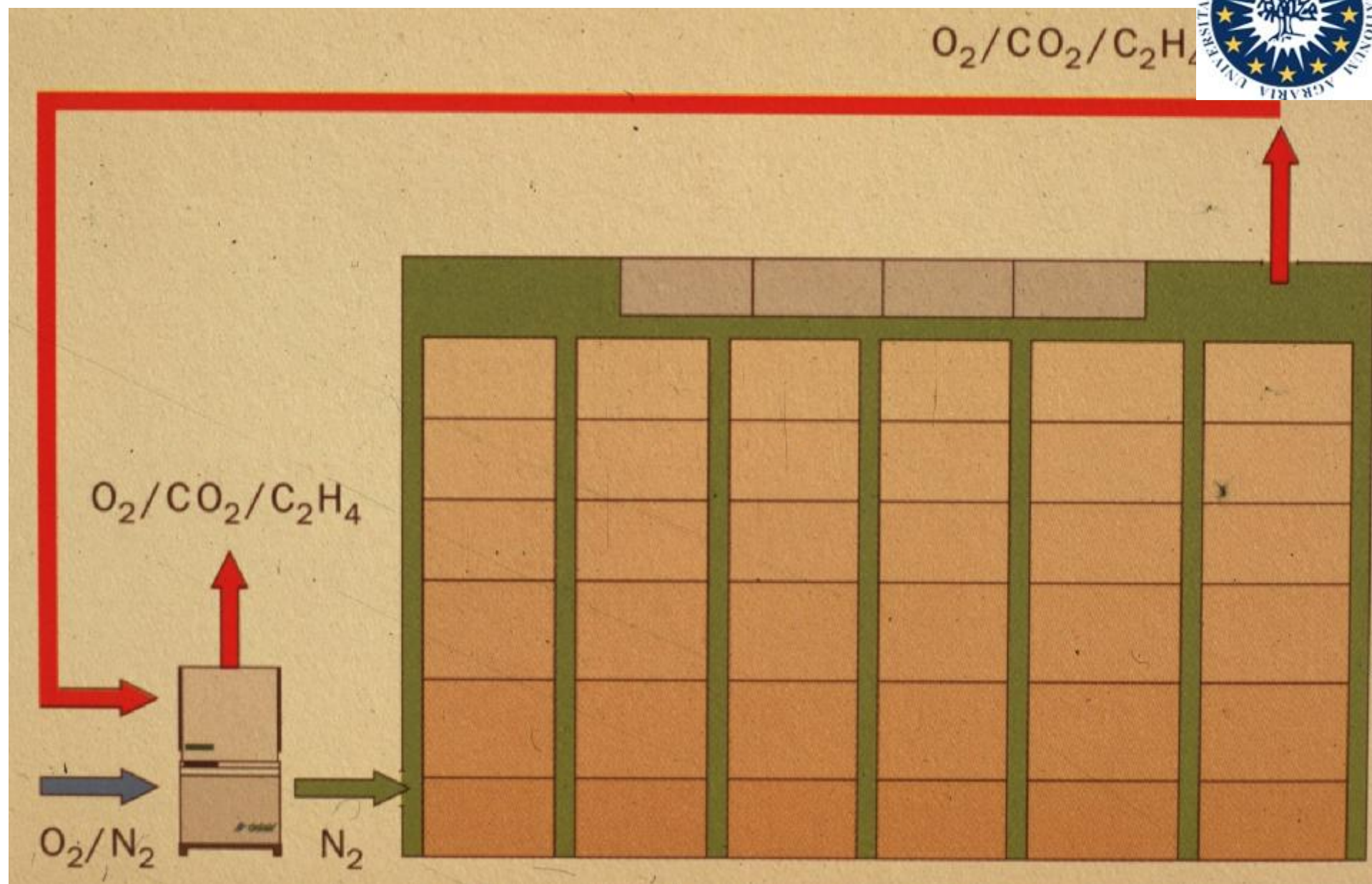


$O_2/CO_2/C_2H_4$

$O_2/CO_2/C_2H_4$

O_2/N_2

N_2

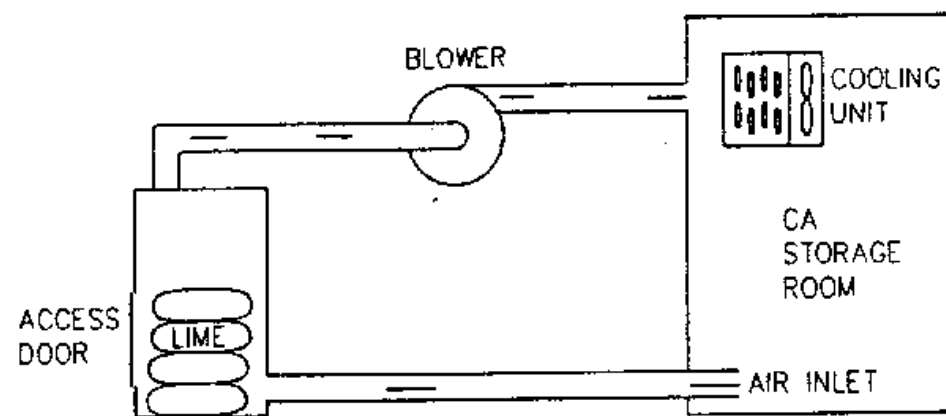




Commercial CA generating equipment

Carbon dioxide removal absorbers

- Water
- Sodium
- Ethanolamine
- Hydrated lime adsorbers
- Activated charcoal
- Molecular sieves

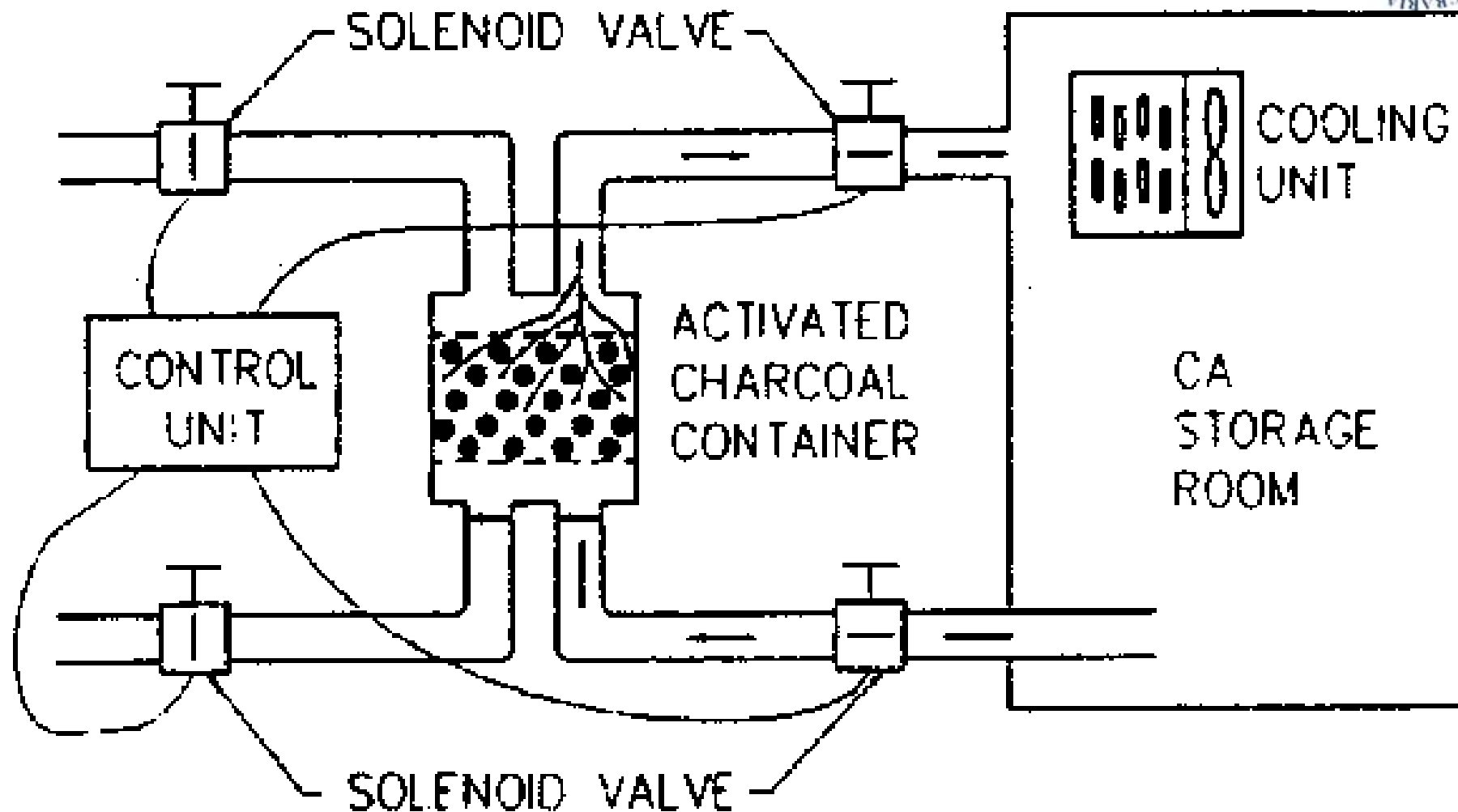


75



74

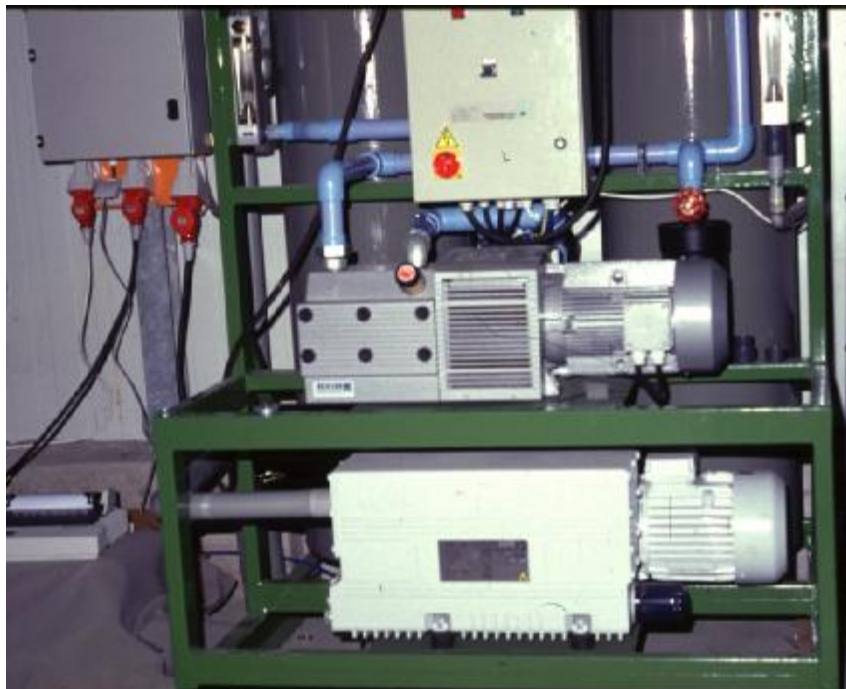
Activated charcoal CO₂ scrubber for CA storage



Activated charcoal CO₂ scrubber for CA storage



Monitoring equipment

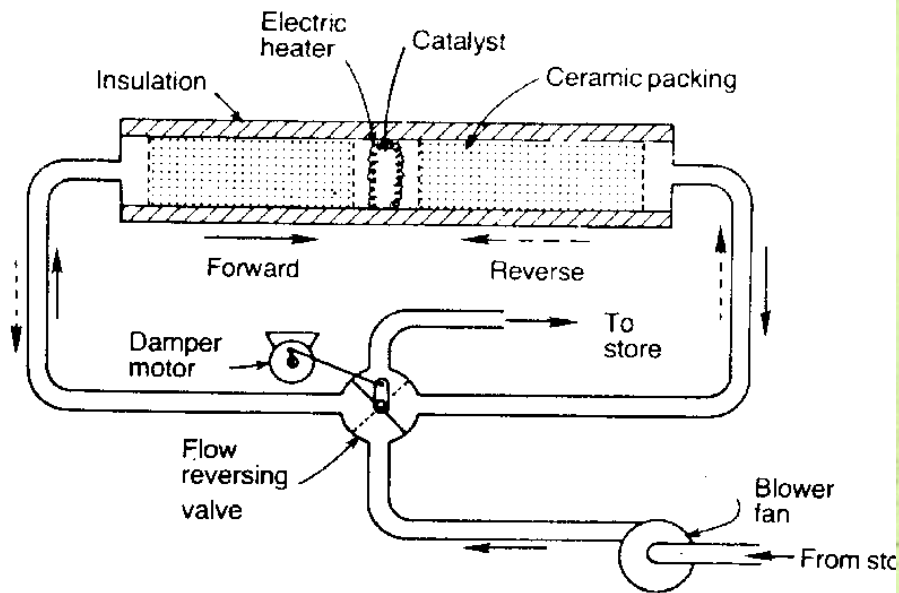


Breather bags (0.35 to 0.4 m³/100m³)



Ethylene control system

Heated catalyst





Gas-tight construction
Insulated panels

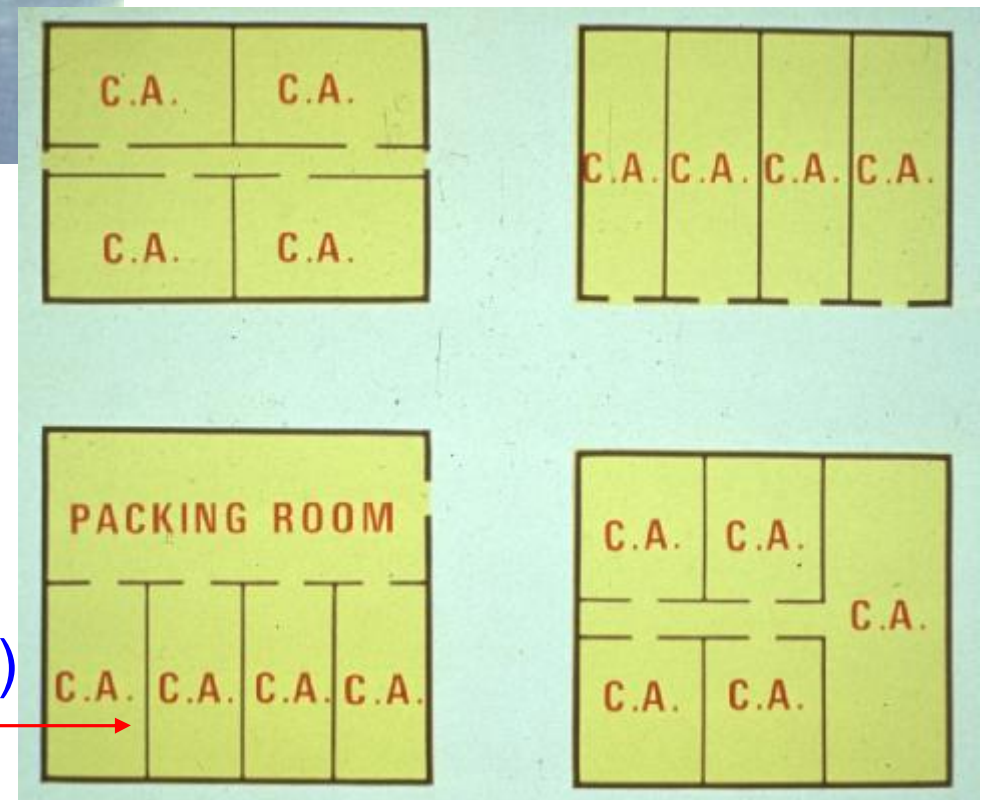


Layouts of CA facilities



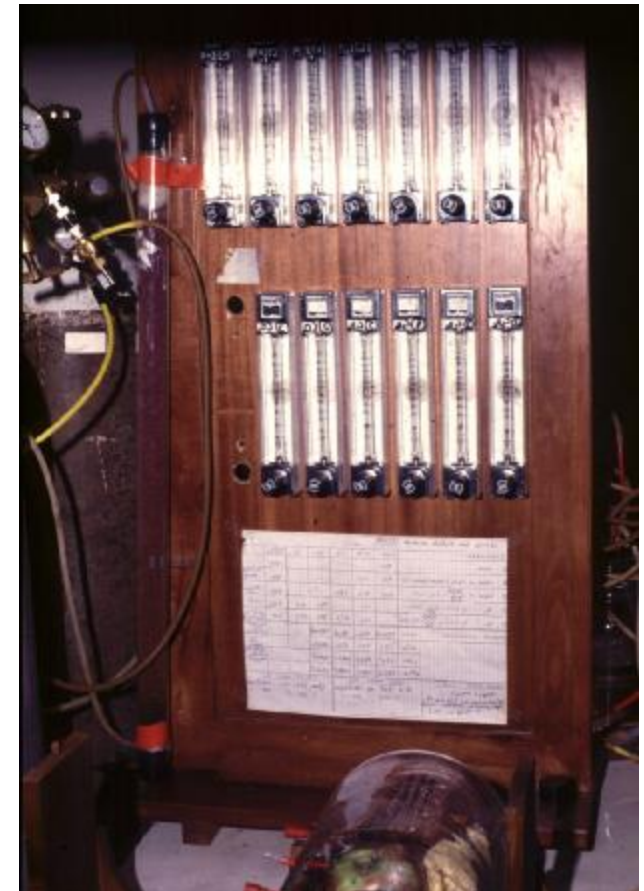
Doors (solid frame clammed tightly
against door frame)

Room size (50-400 tons)





Experimental equipment



Safety considerations



CA STORAGE SAFETY
Caution Labels

CAUTION Low Oxygen

DO NOT ENTER if room is sealed

You will Pass out in 30 seconds

YOU WILL DIE in minutes



CA STORAGE SAFETY

Symptoms of asphyxia

21% oxygen Breathing normal

17% oxygen Candle is extinguisher

12-16% oxygen Breathing increased, pulse accelerated

10-12% oxygen Consciousness continues, injuries

6-10% oxygen Nausea and vomiting

<6% oxygen Loss of consciousness in 30-45 seconds